

ORIGINAL ARTICLE

The Big Finger: the second to fourth digit ratio is a predictor of sporting ability in women

S N Paul, B S Kato, J L Hunkin, S Vivekanandan, T D Spector



See end of article for
authors' affiliations

Br J Sports Med 2006;40:981–983. doi: 10.1136/bjsm.2006.027193

Correspondence to:
Professor Spector, Twin
Research and Genetic
Epidemiology Unit, St
Thomas' Hospital, London
SE1 7EH, UK; tim.
spector@kcl.ac.uk

Accepted 22 August 2006
Published Online First
28 September 2006

Background: The second to fourth finger length ratio (2d:4d) is thought to be related to diverse traits including cognitive ability, disease susceptibility, and sexuality.

Objective: To examine the relationship between 2d:4d and sports ability in women.

Methods: Hand radiographs from 607 women (mean age 54 years) were used to estimate 2d:4d. Ranking of sports ability was on a scale (1–5).

Results: The highest achieved level of participation in any sport was significantly negatively associated with 2d:4d ($b = -4.93$, $p = 0.01$) as was the relationship between 2d:4d and running level ($b = -6.81$, $p = 0.034$). Ability in other sports also showed a negative relationship albeit non-significant.

Conclusions: These results suggest that a low 2d:4d ratio is related to increased female sports ability. It can be postulated that this ratio may predict potential sports ability. Understanding the mechanisms underpinning this relationship may give important insights into musculoskeletal fitness, health and disease.

The ratio of the length of the index finger to the ring finger (2d:4d) has been the subject of much recent research, although the sexually dimorphic nature of this ratio has been reported for over 50 years.¹ There is speculative evidence that this ratio may be established during early fetal life,² and there is some evidence that associates the prenatal sex hormone environment with 2d:4d.³ It also appears that the ratio is stable during life.^{4–5} In most reported studies, males tend to have a lower 2d:4d.

Diverse phenotypes (including sperm counts, reproductive success, sexual orientation, autism, age at development of breast cancer, age at development of myocardial infarction, musical ability, resistance to toxoplasma infection, and aspects of cognitive ability and personality) have all been associated with 2d:4d, although results have often been conflicting and based on small sample sizes.⁶ Ability in soccer, athletics and middle distance running has also been reported to have an association with 2d:4d, but published studies to date have been performed near exclusively in male participants.⁴

The aim of this study was to examine the association between sports ability (determined by highest level of sports competition achieved) and radiographically determined 2d:4d in female participants.

METHODS

Participants

The study participants comprised women recruited from the St Thomas' Adult Twin Registry (Twins UK)⁷ (www.twinsuk.ac.uk). Only female twins were included as no male twins had hand radiographs performed. Recruitment has been described elsewhere,⁸ and participants were unaware of any particular hypotheses being tested. Zygosity was determined by genotyping. The St Thomas' ethics committee approved the study, and written consent was obtained from all participants.

Radiographs

Radiographs of both hands were taken from the dorsal surface at 55 KVp, 5 mA at a collimator distance of 100 cm. With digital vernier callipers measuring to 0.01 mm, the lengths of the second and fourth fingers of each hand were

measured from the proximal end of the proximal phalanx to the distal tip of the distal phalanx. Radiographs were excluded in the presence of total or partial amputation of the second or fourth digit, evidence of arthropathy, or indistinct/unreadable images. Ratios were calculated by dividing the length of the second digit by the fourth. Mean 2d:4d was calculated from the ratios for the right and left hand.

A single reader conducted all the measurements. Finger lengths from hand radiographs of 31 twin pairs were read twice on a standard horizontal light box with an interval of a week to test reproducibility. Repeatability of finger lengths was calculated as an intraclass correlation coefficient and was very high (0.99) for all lengths. Repeated measures analysis of variance was used to calculate the ratio between group mean squares and error mean squares (F value). The between-individual variance was far greater than the measurement error for all lengths (right second finger length $F = 406$, $p = 0.039$; right fourth finger length $F = 2315$, $p = 0.0052$; left second finger length $F = 676$, $p = 0.0305$; left fourth finger length $F = 451$, $p = 0.037$). From these

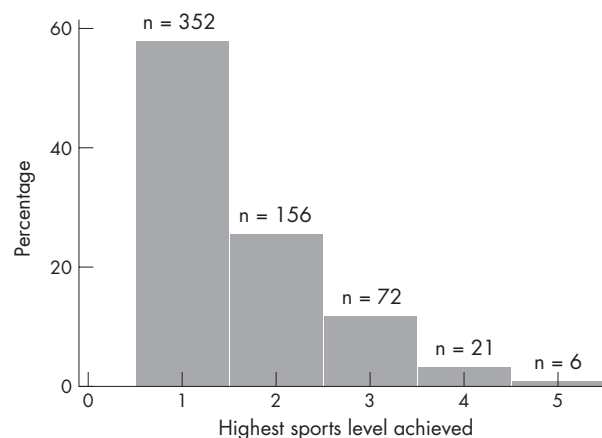


Figure 1 Proportion of individuals in each sports level category (n = absolute numbers).

findings, we established that our measurements were highly repeatable and reflected real differences between participants.

Determination of sports ability

During 2000, participants were asked to rank the highest level achieved in a list of 12 sports (swimming, cycling, running, gymnastics, tennis, badminton, squash, golf, skiing, soccer, cricket, martial arts) from the age of 11 years on a questionnaire designed for this purpose. If subjects had participated in a particular activity, they were asked to circle the highest competitive level in that activity (1 = social participation only, 2 = school team level, 3 = club/university team level, 4 = county level, 5 = national level). A similar scale has been used to rank middle distance runners and was shown to correlate with best 800 m times elsewhere.⁹ Subjects selected sports participation level without knowledge of their co-twin's response. Scorers were similarly blinded to the hypothesis being tested.

Data handling and analyses were performed using STATA release 8 (StataCorp LP, 4905 Lakeway Drive, College Station, Texas, USA; <http://www.stata.com/>). Robust regression was used to account for the effects of non-independence of twin pairs.

RESULTS

Complete data were available on 607 participants. The mean (SD) age was 53.8 (8.5) years (range 25–79). Mean (SD) right 2d:4d was 0.925 (0.021) and left 2d:4d 0.928 (0.021), and mean 2d:4d for both hands was 0.927 (0.019) (range 0.864–0.979). The ratio in both hands was normally distributed (skewness = -0.12, kurtosis = 3.13).

A large number (79%) of subjects recorded participation in swimming, 61% in cycling, 40% in tennis, and 37% in running. Figure 1 illustrates the percentage achieving sport levels 1–5. The overall highest age-adjusted level achieved in any sport was significantly negatively associated with mean 2d:4d ($b = -4.93$, $p = 0.01$) (fig 2). When analysed separately, mean 2d:4d was significantly negatively associated with running level ($b = -6.81$, $p = 0.034$). Most other sports had negative associations with 2d:4d, but failed to reach significance individually. Some of the strongest negative associations were with soccer playing individuals ($b = -7.66$), but numbers were small ($n = 12$). Only cricket, martial arts and gymnastics showed non-significant trends in the opposite direction.

In all, 87.9% of participants were right handed, 10.2% left handed, 1.2% ambidextrous and 0.7% were of unknown handedness.

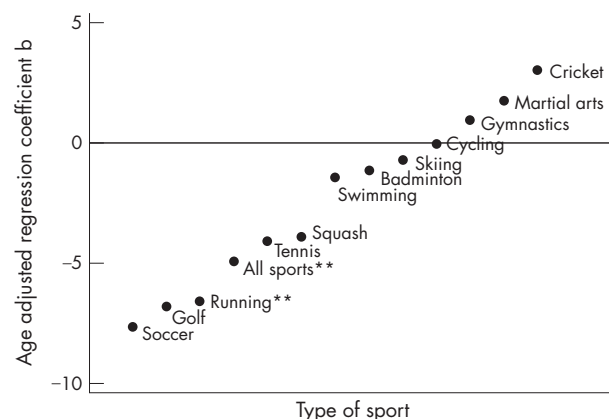


Figure 2 Regression scatterplot (** $p < 0.05$).

DISCUSSION

Published data on sporting ability and 2d:4d thus far has mainly focused on male participants. Manning and Taylor¹⁰ explored the relationship between this skeletal ratio by direct 2d:4d measurement and sports rank (self recorded on a 1–10 scale, 10 indicating international participation) in 128 men. Some 45% of participants practised running, 14% football, 10% martial arts, 8% rugby, 8% tennis or squash, 7% swimming and 5% hockey. They found a significant negative relationship ($b = -22.73$, $F = 10.99$, $p = 0.01$) between 2d:4d and sports rank even when the effects of age, sports experience and type of sport were removed. As part of the same study, the authors contrasted photocopied 2d:4d in 304 current or historical male participants in professional English soccer and 533 controls. Professional players had a significantly lower 2d:4d (derived from right and left 2d:4d) compared with controls. Internationals had a significantly lower mean 2d:4d than non-international players. From these data, the authors felt that 2d:4d in men is a correlate for ability in many sports, including football. They hypothesised that this relationship may arise through the influence of prenatal testosterone on development of the right hemisphere and visuospatial ability, and/or through environmental effects of prenatal sex hormone and developmental stability of the cardiovascular system. These effects may be of clear benefit in the development of a sporting individual.

Similar results were obtained when the relationship between directly measured 2d:4d and fastest dry slope skiing time was examined in 72 competitive skiers (52 men, 20 women) and controls matched for age, sex and ethnicity.¹¹ Controls had a higher mean 2d:4d than skiers, and a lower 2d:4d correlated with a quicker course time, this relationship being independent of sex, age and experience. Aside from significant sex differences in mean 2d:4d, specific data relating to the female cohort were not presented.

This is the largest study to date exploring the relationship between female sports ability and 2d:4d across a wide range of sports. It lends support to recent smaller studies that show female sports ability and fitness appear to be negatively associated with 2d:4d.^{12–13} The strongest association appears to hold for running when analysed in isolation, although trends towards a negative association with 2d:4d were observed for many of the individual sports. This may be because running forms a common integral part of many of the sports examined or their training schedules. Our study was underpowered to examine associations between participation level in all of these sports and 2d:4d because of small numbers in particular sports. No data were available to adjust for sports experience and type of sport, but this is being evaluated as part of an ongoing prospective study.

If 2d:4d is fixed before birth and remains constant during life, this offers up the tantalising question: can 2d:4d be used to predict future potential in sport? Prediction of future ability is ascertained in many aspects of education, and several researchers have attempted to look at particular characteristics that may predict suitability/future excellence in sport. Testing the theory that future ability and performance in sports may be reliably predicted by 2d:4d would require a large prospective study following children from a young age through to their competitive peak in their chosen event, although the performance of childhood athletes may not correlate well with best adult performance because of variability in developmental rate.⁴ Detection of sports potential by examining 2d:4d—for example, as part of a talent identification programme—may, however, help to identify talented individuals at a pre-competitive stage. Potentially of more interest is determining the exact biological correlate of 2d:4d that influences sports ability. Although developmentally important homoeobox mutations

What is already known on this topic

- The second to fourth finger length ratio is thought to be related to diverse traits including cognitive ability, disease susceptibility, and sexuality.

What this study adds

- A low second to fourth finger length ratio is related to increased female sports ability.
- It can be postulated that this ratio may predict potential sports ability.

have been linked to abnormalities in the development of digits and gonads, no specific gene candidates have been identified for the determination of 2d:4d, and therefore it is likely that this skeletal ratio is under polygenetic influence. In a classical twin study, we have recently shown that 2d:4d shows strong heritability with relatively little influence of common environment,¹⁴ and this may explain why sporting parents often have sporting children.

A possible source of conflicting data is the method of measurement. Most work on 2d:4d has involved measuring finger lengths from hand photocopies, which reduces collection time and provides a permanent record; this form of measurement may yield lower ratios than direct finger measurements,¹⁵ although correlation is reportedly high for both these methods.¹⁶ Manning *et al*¹⁷ confirmed that measurements of 2d:4d from hand photocopies and radiographs are significantly correlated, although mean radiograph-derived 2d:4d showed less sexual dimorphism, and ratios were lower than those derived from photocopies. The authors suggested that this may be because photocopy measurement includes measuring soft tissue as well as bone lengths.

Recall bias is a possible source of error as there was no independent verification of sports level achieved. However, this is likely to be small, as subjects are unlikely to forget competition at national and sub-national level. Owing to small numbers, it was difficult to draw firm conclusions for certain groups. Selection bias is unlikely to be a problem in our study, as x ray examinations were performed for other reasons. Also, the study population has been found to be similar to a population-based singleton sample for a number of common medical conditions and lifestyle characteristics.¹⁸

In conclusion, using a precise radiographic phenotype we have provided evidence that low 2d:4d is related to increased running and sporting ability in women. We postulate that 2d:4d is a predictor of potential sports ability. Understanding the mechanisms underpinning this relationship would give important insights into musculoskeletal fitness, health and disease. Further work may determine whether this ratio can be used at a pre-competitive stage to predict future ability.

ACKNOWLEDGEMENTS

TwinsUK is supported by The Wellcome Trust, The Arthritis Research Campaign, The Chronic Disease Research Foundation, and the EU Biomed program. We are grateful to all the staff of the Twin Research

and Genetic Epidemiology Unit at St Thomas' Hospital who helped to collect data, and all the twins who participated in this study.

Authors' affiliations

S N Paul, B S Kato, J L Hunkin, S Vivekanandan, T D Spector, Twin Research and Genetic Epidemiology Unit, St Thomas' Hospital, London, UK

Competing interests: None declared.

REFERENCES

- 1 Phelps VR. Relative index finger length as a sex influenced trait in man. *Am J Hum Genet* 1952;4:472-89.
- 2 Phelps VR, Garn SM, Burdi AR, *et al*. Early prenatal attainment of adult metacarpal-phalangeal rankings and proportions. *Am J Phys Anthropol* 1975;43:327-32.
- 3 Lutchmaya S, Baron-Cohen S, Raggatt P, *et al*. 2nd to 4th digit ratios, fetal testosterone and estradiol. *Early Hum Dev* 2003;77:23-8.
- 4 Manning JT. *Digit ratio*. New Brunswick, NJ: Rutgers University Press, 2002.
- 5 McIntyre MH, Ellison PT, Lieberman DE, *et al*. The development of sex differences in digital formula from infancy in the Fels Longitudinal Study. *Proc Biol Sci* 2005;272:1473-9.
- 6 Putz DA, Gaulin SJC, Sporter RJ, *et al*. Sex hormones and finger length: what does 2D:4D indicate? *Evol Hum Behav* 2004;25:182-99.
- 7 Spector TD, MacGregor AJ. The St Thomas' UK Adult Twin Registry. *Twin Res* 2002;5:440-3.
- 8 Spector TD, Cicuttini F, Baker J, *et al*. Genetic influences on osteoarthritis in women. A twin study. *BMJ* 1996;312:940-3.
- 9 Manning JT, Pickup LJ. Symmetry and performance in middle distance runners. *Int J Sports Med* 1998;19:205-9.
- 10 Manning JT, Taylor RP. Second to fourth digit ratio and male ability in sport: implications for sexual selection in humans. *Evol Hum Behav* 2001;22:61-9.
- 11 Manning JT. The ratio of 2nd to 4th digit length and performance in skiing. *J Sports Med Phys Fitness* 2002;42:446-50.
- 12 Pokrywka L, Rachon D, Suchecka-Rachon K, *et al*. The second to fourth digit ratio in elite and non-elite female athletes. *Am J Hum Biol* 2005;17:796-800.
- 13 Honekopp J, T Manning J, Muller C. Digit ratio (2D:4D) and physical fitness in males and females: evidence for effects of prenatal androgens on sexually selected traits. *Horm Behav* 2006;49:545-9.
- 14 Paul SN, Kato BS, Cherkas LF, *et al*. Heritability of the second to fourth digit ratio (2d:4d): a twin study. *Twin Res Hum Genet* 2006;9:215-19.
- 15 Manning JT, Fink B, Neave N, *et al*. Photocopies yield lower digit ratios (2D:4D) *Arch Sex Behav* 2005;34:329-33.
- 16 Robinson SJ, Manning JT. The ratio of 2nd to 4th digit length and male homosexuality. *Evol Hum Behav* 2000;21:333-45.
- 17 Manning JT, Trivers RL, Thornhill R, *et al*. 2nd to 4th digit ratio and asymmetry of hand performance in Jamaican children. *Laterality* 2000;5:121-32.
- 18 Andrew T, Hart DJ, Sneider H, *et al*. Are twins and singletons comparable? A study of disease-related and lifestyle characteristics in adult women. *Twin Res* 2001;4:464-77.

COMMENTARY

In an era when genetic testing to predict athletic performance has come to the forefront, the authors present an interesting analysis of a simple ratio of the length of the second and fourth fingers and correlate this with athletic success. Complex studies of gene polymorphism in elite athletes are on the verge of identifying specific genetic clusters that may favour either endurance or strength development. Most clinicians will find fascinating the concept that we can identify specific physical markers on examination that may allow us to predict sports success without the more sophisticated testing. Additional research must identify the links between physical findings, physiology and genetics to better understand how these relate.

K B Fields

Moses Cone Health System, Greensboro, NC, USA;
bert.fields@mosescone.com